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RADIOACTIVITY OF NATURAL WATERS

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All natural waters contain radioactive elements, but few are enriched in them to such an extent that they merit the name of radioactive waters. While in rock occurrences these elements are in equilibrium with each other, there is, as a rule, no such equilibrium in natural waters. Radioactive waters are subdivided into radon, radium, radon-radium, radium-mesothorium, uranium-radium waters, etc., depending on the prevalence of some particular element or elements.

It is of interest to consider how these waters are formed, in view of the fact that radium waters, in particular, are very valuable: they may be a source of formation of medically active radon waters, or radium may be obtained from them. Radium, as a rule, does not enter into the crystal lattice of minerals: it is contained in microscopic cracks and empty spaces (the so-called capillaries), being either dissolved in the water filling the capillaries or adsorbed at their walls. Thus, radium may get into the waters not only when solution occurs (such waters are rare and as a rule are uranium-radium waters rather than simply radium waters), but also when the chemical composition of the water is such that leaching out of radium from the rocks takes place. In this process of leaching out, radium goes into solution without destruction of the crystal lattice and without any appreciable adsorption at the walls of the capillaries or of any other ducts through which the water flows.

The conditions outlined above are not in themselves sufficient for radium water to be formed. A noticeable concentration of radium in the water can only result if this element comes steadily from the depth of the capillaries. However, diffusion form the finest capillaries proceeds slowly. Of importance are the duration of the contact between the water and the rock (the "age" of the

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water), the length of the stretch over which this contact takes place, the structure of the rock, i.e., the nature of the network of capillaries in it), etc. Only when conditions are favorable in every respect, a water strongly enriched in radium may result.

It is clear that conditions which favor enrichment of radium will also favor enrichment of its isotopes, i. e., mesothorium I, thorium X, and actinium X. When water contains an increased concentration of radium, the concentration of these isotopes is also likely to be higher. However, waters of this type, although considerably enriched in radium and its isotopes, contain almost no uranium, even though they may flow through rocks containing large quantities of this element. Apparently, the conditions mentioned above, which are favorable for enrichment of the water in radium, do not at all exclude enrichment in uranium. Such waters are also poor in radon.

In view of the fact that radon is a noble gas, the chemical composition of the water has no effect on the absorption of this element by the water. Natural waters frequently dissolve radon which is continuously evolved by rocks as a result of the radioactive decay taking place in them. The evolution of radon from such emanating rocks varies depending on the structure of the rock, on the nature of the capillaries in it, and on the degree of destruction which the crystal lattice has undergone. When the degree of destruction of the crystal lattice is high, as in tectonic regions, areas of contact between different kinds of rocks, or zones of crushing, the emanating capacity of rocks is higher and the waters in contact with them contain more radon.

However, this type of enrichment with radon is not the only one. Furthermore, waters enriched with radon through contact with primacy radioactive rocks rarely contain a high concentration of this element. Considerable enrichment in radon takes place when radium waters participate in the process of enrichment. This happens when waters which have a definite chemical composition and may not even contain a high concentration of radium pass for years over fissures containing loose, porous deposits, or clays, loams, and several other varieties of geological occurences. Then there is considerable adsorption of radium from the water and formation of radioactive foci of a definite extent and perimeter. The emanating capcity of the geological occurrence, and consequently also the evolution of radon, are strongly enhanced at such foci. In comparison with primary uranium rocks, radium is nearer to the surface which is in contact with water at these foci, so that highly active radon waters result.

Increased radioactivity of rocks does not necessarily mean that water which comes into contact with them will acquire a high radon content. An adequate time of contact is required for this. The dimensions of the radioactive zone (focus), the rate of seepage of the water, and the capacity for water retention exhibited by the particular rock occurrence as well as its porosity are also of importance.

The highest content of radioactive elements is found in subterranean waters. The content of radium in such waters reaches several millionths of a milligram per liter, that of uranium, several hundredths of a milligram per liter, and that of radon, several thousand Mache units (a Mache unit measures the concentration of radon in water or air and is equal to 3.64×10^{-10} Curie units per liter. A Curie unit is the quantity of radon which is in radioactive equilibrium with 1 gr of radium). The waters of rivers, seas, and the ocean also contain radioactive elements, but in considerably smaller quantities. Some deep-sea deposits exhibit an appreciable radioactivity, however.

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In view of the fact that radioactive waters are of value for therapeutic purposes and that they may yield the valuable element radium, great attention is being paid in the USSR to the study of their formation. Due to the efforts of Academicians V. I. Vernadskiy and V. G. Khlopin, the science of radioactive waters originated and was developed in the USSR. Soviet scientists carried out many investigations in which they studied the laws of the formation of radon waters, radium waters, and other radioactive waters. As a result of this work, the search for radioactive waters was put on a strictly scientific basis.

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